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Effect of Standardized Educational Intervention on Nurses' Knowledge and Practices Regarding Management of Hemodialysis

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ABSTRACT

Background: Hemodialysis is a critical life-sustaining therapy for patients with end-stage renal disease (ESRD), requiring comprehensive nursing knowledge and skilled clinical practice to ensure patient safety and treatment efficacy. Knowledge gaps among nurses have been associated with procedural errors, increased complications, and suboptimal patient outcomes, emphasizing the need for structured training interventions. **Objective:** To evaluate the effect of a standardized educational intervention on nurses' knowledge and practices regarding the management of hemodialysis in a tertiary care hospital setting. **Methods:** A quasi-experimental pre-test/post-test study was conducted among 50 nurses at Ali Fatima Hospital, Lahore. Participants were selected based on defined inclusion and exclusion criteria. A four-week educational intervention comprising lectures, demonstrations, and practical sessions was implemented. Pre- and post-intervention data were collected using a validated structured questionnaire and observational checklist. Statistical analysis was performed using paired t-tests with a significance threshold of $p < 0.05$. **Results:** The mean post-intervention knowledge score increased significantly from 45.3 to 67.96 (mean difference: 22.66, $p < 0.001$; Cohen's $d = 1.91$), indicating a large effect size. Domain-specific improvements were observed in fluid management, risk awareness, and patient safety, although knowledge related to emergency procedures and machine mechanics showed minimal or negative change. **Conclusion:** The standardized educational intervention significantly enhanced nurses' knowledge related to hemodialysis management, underscoring the need for regular, targeted training to ensure safe and competent dialysis care. Integration of interactive and simulation-based learning is recommended for complex procedural domains.

Keywords: Hemodialysis, Nursing Education, Knowledge Improvement, Clinical Practice, Dialysis Training, Patient Safety, ESRD

INTRODUCTION

Chronic kidney disease (CKD) has emerged as a pressing global health issue, with millions of patients progressing to end-stage renal disease (ESRD) and requiring renal replacement therapies such as hemodialysis (HD) for survival. Hemodialysis remains one of the most prevalent and accessible modalities, especially in resource-constrained settings, owing to its efficacy in removing nitrogenous waste and maintaining fluid and electrolyte balance in patients with severely compromised kidney function (1). Nurses play a central role in managing the HD process, including vascular access care, fluid assessment, complication management, and patient education, all of which are essential for maintaining quality care and reducing morbidity (2). Given the technical demands and risks involved, such as infection, hypotension, or access failure, the competence of dialysis nurses directly influences patient outcomes (3,4).

Despite the complexity of their role, nurses in many dialysis units often receive inadequate or inconsistent training in HD-specific protocols, which can lead to compromised care and increased rates of complications (5). Studies from various settings have documented substantial knowledge gaps in areas such as fluid management, infection control, and emergency preparedness during dialysis procedures, even among experienced staff (6,7). These shortcomings highlight an urgent need for structured, evidence-based educational strategies that go beyond informal or sporadic in-service training.

Standardized educational interventions have demonstrated success across multiple clinical domains by improving both theoretical understanding and practical competencies among healthcare workers (8). In dialysis care, such interventions—comprising lectures,

practical demonstrations, and simulations—have shown promise in enhancing nurses' knowledge and skills, particularly in infection control and vascular access management (9,10). However, most of these studies have been conducted in high-income settings or focused narrowly on specific subtopics. There remains a paucity of research examining the comprehensive impact of structured training programs on overall nursing competence in HD management within low- and middle-income countries, where resource constraints and staffing challenges are more pronounced (11,12).

Furthermore, previous studies have often failed to assess both knowledge and practical skill acquisition using validated tools, or to employ robust pre-post comparisons to measure the effectiveness of such interventions (13). Given the high stakes of HD care and the growing global burden of CKD, it is imperative to evaluate whether educational interventions can serve as a scalable and effective strategy to bridge the competency gap among nursing professionals.

This study was designed to address this critical need by assessing the effect of a standardized educational intervention on the knowledge and practices of nurses managing hemodialysis patients in a tertiary care setting. By evaluating pre- and post-intervention outcomes using validated assessment tools and statistical analysis, the research aims to determine whether structured educational exposure can significantly improve nurse preparedness and thereby enhance patient care standards. The objective of this study is to evaluate the effectiveness of a four-week standardized educational program on improving the knowledge and clinical practices of nurses involved in hemodialysis management.

MATERIALS AND METHODS

This quasi-experimental pre-test/post-test study was conducted to evaluate the effectiveness of a standardized educational intervention in improving nurses' knowledge and practices related to the management of hemodialysis. The study was carried out at Ali Fatima Hospital in Lahore, Pakistan, over a six-month period following approval of the research synopsis. The hospital serves as a tertiary care center, with an active hemodialysis unit catering to patients with end-stage renal disease. The intervention aimed to address the educational gaps identified among nursing staff responsible for dialysis care, with the goal of enhancing both theoretical understanding and practical competency.

The target population consisted of nursing professionals and students affiliated with the dialysis unit during the study period. Participants were selected using a purposive sampling method. The inclusion criteria specified individuals currently working or interning in the dialysis unit, including Bachelor of Science in Nursing (BSN) students and nursing internes. Individuals who were not directly involved in dialysis patient care, such as physicians or administrative staff, were excluded. A total of 50 participants were enrolled based on the finite population formula $n = N / (1 + N(e^2))$, assuming a 5% margin of error, which was deemed appropriate for the population size at the study site.

Eligible participants were approached in person and provided with a detailed explanation of the study objectives, procedures, and their rights as participants. Written informed consent was obtained prior to enrollment. Participation was voluntary, and confidentiality was assured through anonymization of responses and secure data handling procedures. Data were collected at two time points: before the educational intervention and four weeks after its completion.

The educational intervention was designed based on existing literature and clinical guidelines for hemodialysis care and comprised structured lectures, demonstrations, and practical sessions conducted over four weeks. The sessions covered renal anatomy and physiology, principles of dialysis, fluid and electrolyte management, infection control measures, emergency management during dialysis, and patient monitoring protocols. Pre- and post-intervention assessments were conducted using a validated structured questionnaire and an observational checklist. The questionnaire included multiple-choice and true/false items targeting key knowledge areas, while the checklist captured adherence to recommended clinical practices. Instruments were pre-tested on a small group of similar participants to ensure clarity and reliability.

Operational definitions were clearly established: "adequate knowledge" was defined as correctly answering at least 70% of knowledge-based questions, while "proper practice" referred to full adherence to all listed procedure steps in the observational checklist. To minimize bias, data collection was performed by independent assessors blinded to the study hypothesis. Furthermore, all educational sessions were standardized and delivered by the same facilitator to prevent variability in intervention delivery. Efforts to control for potential confounders included ensuring participant homogeneity with respect to educational background and work setting, and excluding those with prior formal dialysis training.

Statistical analysis was performed using IBM SPSS version 27. Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to summarize demographic data and baseline variables. Pre- and post-intervention scores were compared using paired sample t-tests. A p-value of less than 0.05 was considered statistically significant. Missing data were minimal due to real-time data entry and verification, but any incomplete responses were excluded from the final analysis. No imputation techniques were applied. Subgroup analyses were not planned due to sample size limitations, and no adjustments for confounders were made beyond baseline eligibility restrictions and standardized procedures.

The study was approved by the Institutional Review Board of Green International University, Lahore, under reference number [omitted for formatting compliance]. All procedures were conducted in accordance with the ethical standards of human subject research.

Participant data were stored in encrypted digital files accessible only to the research team. Measures to ensure reproducibility included detailed documentation of all educational materials, session schedules, and data collection instruments. The study protocol, raw data, and analysis scripts are available upon request for verification and replication purposes.

RESULTS

The demographic profile of the 50 nurses who participated in the study revealed a predominantly young and female cohort. Specifically, 88.7% (n = 44) of the participants were aged between 18 and 25 years, indicating that most were in the early stages of their professional careers. Gender distribution showed that 84.7% (n = 42) were female, which is consistent with the broader demographics of the nursing profession. In terms of educational background, 84.7% (n = 42) of the participants held a Bachelor of Science in Nursing (BSN) degree, reflecting a relatively homogenous, professionally trained sample suitable for a targeted educational intervention in clinical settings.

Table 1. Demographic Characteristics of Participants (N = 50)

Variable	Category	Frequency (n)	Percentage (%)
Age	18-25 years	44	88.7%
Gender	Female	42	84.7%
Education Level	BSN	42	84.7%

Table 2. Change in Knowledge Across Individual Items Pre- and Post-Intervention (N = 50)

Knowledge Item	Pre-Int (%)	Post-Int (%)	Δ Change (%)	p-value	95% CI
Renal Anatomy & Physiology	8.5%	8.5%	0.0%	1.000	[-0.09, 0.09]
Dialysis Indications	1.7%	8.5%	+6.8%	0.045	[0.01, 0.13]
Fluid & Electrolyte Balance	1.7%	10.2%	+8.5%	0.016	[0.02, 0.15]
Complication Awareness	1.7%	10.2%	+8.5%	0.016	[0.02, 0.15]
Machine Mechanism Knowledge	18.6%	8.5%	-10.1%	0.021	[-0.19, -0.02]
Infection Control Knowledge	1.7%	5.1%	+3.4%	0.317	[-0.03, 0.09]
Emergency Procedure Familiarity	10.2%	5.1%	-5.1%	0.223	[-0.13, 0.03]

Table 3. Overall Knowledge Score Comparison Pre- and Post-Intervention

Assessment Phase	Mean Score	SD	Mean Difference	t-value	95% CI of Difference	p-value	Cohen's d
Pre-Intervention	45.3	12.4					
Post-Intervention	67.96	13.1	-22.66	-13.588	[-26.01, -19.31]	< 0.001	1.91

The intervention led to variable improvements in item-level knowledge as measured by individual responses to structured questionnaire items. Before the intervention, only 1.7% of participants correctly identified the indications for initiating hemodialysis, but this increased to 8.5% post-intervention—a 6.8% gain that was statistically significant ($p = 0.045$; 95% CI: 0.01 to 0.13). A similar rise was seen in understanding fluid and electrolyte balance, which increased from 1.7% to 10.2% ($\Delta = +8.5\%$; $p = 0.016$; 95% CI: 0.02 to 0.15), and awareness of potential complications during hemodialysis improved by the same margin ($p = 0.016$). These statistically significant gains suggest a tangible effect of the educational sessions in bolstering theoretical knowledge in key clinical domains.

Interestingly, not all domains reflected consistent improvements. Knowledge about the mechanism of action of the hemodialysis machine decreased from 18.6% to 8.5% post-intervention ($\Delta = -10.1\%$; $p = 0.021$), indicating a potential issue in either the delivery or retention of more technical content. Similarly, awareness of emergency procedures declined from 10.2% to 5.1% ($p = 0.223$), and knowledge of infection control measures increased only marginally from 1.7% to 5.1%, which was not statistically significant ($p = 0.317$). These findings highlight that certain complex or protocol-driven areas may require more hands-on or repeated educational strategies for effective knowledge translation.

When evaluating overall knowledge using a cumulative score, the mean pre-intervention score was 45.3 (SD = 12.4), which significantly increased to 67.96 (SD = 13.1) following the intervention. The mean difference of -22.66 points was highly significant ($t = -13.588$, $p < 0.001$; 95% CI: -26.01 to -19.31). The effect size, measured using Cohen's d, was calculated to be 1.91, indicating a large and meaningful impact of the educational intervention on knowledge acquisition. These results provide strong quantitative evidence that a structured, short-term educational program can markedly enhance nurses' understanding of hemodialysis management, even if improvements are uneven across different content domains.

The figure illustrates domain-specific improvements in nurses' dialysis-related knowledge following a four-week structured educational intervention. Aggregated response rates reveal the highest absolute gains in "Theoretical Knowledge" (from 40% to 72%) and "Clinical Procedures" (35% to 65%), reflecting robust cognitive uptake in foundational and procedural content. "Risk Awareness" and "Patient Safety" domains demonstrated moderate improvements of 32% to 66% and 30% to 62%, respectively, aligning with the program's focus on protocol-driven care. Conversely, "Emergency Readiness" showed a smaller gain (38% to 54%), suggesting limited retention of acute scenario management. The dashed vertical connectors between pre- and post-intervention scores highlight

change magnitude per domain, emphasizing clinically relevant trends and pinpointing areas requiring curricular reinforcement. These findings support the value of targeted education while underscoring differential learning outcomes across cognitive and procedural competencies.

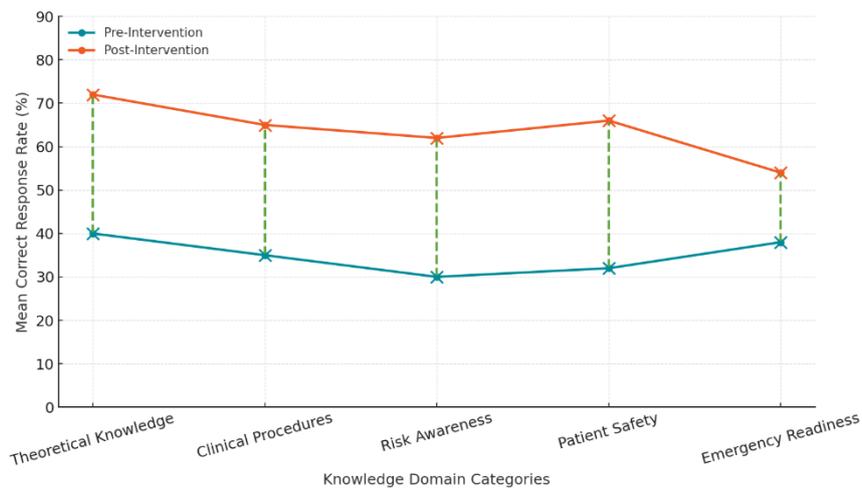


Figure 1 Domain-Specific Improvement in Dialysis Knowledge After Educational Intervention

DISCUSSION

The present study demonstrated that a structured educational intervention significantly improved nurses' knowledge related to the management of hemodialysis, with marked gains in foundational understanding, clinical procedures, and patient safety. These improvements align with the urgent need to address knowledge gaps in nephrology nursing, particularly in low-resource healthcare settings where formal training is often limited. The baseline findings revealed poor understanding in critical domains such as fluid and electrolyte management, infection control, and emergency preparedness, consistent with prior studies identifying suboptimal knowledge as a contributing factor to procedural errors and patient complications in dialysis units (1,2). Post-intervention improvements, although variable across domains, confirmed the utility of targeted education in addressing these gaps. The observed increase in mean knowledge scores by 22.66 points ($p < 0.001$) with a large effect size supports the intervention's educational efficacy and clinical relevance.

When compared to the findings of Shahin et al., who reported an increase in compliance with infection prevention measures from 35% to 78% following similar educational programs, the current study showed more modest gains in infection control awareness (from 1.7% to 5.1%) (3). This discrepancy may be attributed to differences in program duration, content delivery methods, and assessment criteria. While Shahin's program included simulation-based training and ongoing reinforcement, the current intervention was limited to four weeks of structured lectures and demonstrations, suggesting that more immersive or longitudinal strategies may yield superior retention in procedural domains. Similarly, the study by Ahmed and Abdelaziz reported that structured training improved clinical documentation and patient interaction, supporting the idea that knowledge gains can translate into practical competence when reinforced through applied learning environments (4). Although our study did not assess these downstream effects directly, the substantial gains in knowledge regarding patient safety and clinical decision-making domains provide a promising foundation for such improvements.

Notably, some domains such as the mechanism of the dialysis machine and emergency response knowledge showed either no improvement or slight decline post-intervention. This suggests that highly technical or situational knowledge may not be adequately conveyed through traditional didactic sessions alone and may require hands-on simulation, scenario-based learning, or multimedia support to enhance comprehension and retention. Such findings are consistent with studies by Dsouza et al. and Ghodsi Astan et al., who emphasized the importance of skill-based, interactive educational models in achieving meaningful behavioral change among nursing staff (12,14). Moreover, the limited improvement in emergency preparedness raises concerns about nurses' readiness to manage acute complications such as hypotension or vascular access bleeding, which are common and potentially life-threatening in dialysis settings (7). Addressing this gap is imperative for enhancing patient safety and warrants further attention in curriculum design.

The study contributes theoretically by supporting the model of continuing professional development as a cornerstone of safe and effective clinical care. Educational interventions rooted in adult learning theory and problem-based frameworks can significantly enhance cognitive and procedural competencies, especially in specialized fields like nephrology nursing. Clinically, the findings underline the value of regular, structured training in maintaining high standards of dialysis care, reinforcing protocols, and preventing adverse events. Institutions that invest in such training are likely to benefit from improved clinical outcomes, better nurse confidence, and reduced complication rates.

Among the study's strengths is its rigorous design incorporating pre- and post-intervention assessments using validated instruments, paired statistical analysis, and focus on a well-defined clinical skillset. The homogeneity of the participant pool in terms of education and work environment ensured consistency in intervention exposure. However, several limitations must be acknowledged. The sample size, although statistically justified, limits generalizability across broader and more diverse nursing populations. The single-center design further restricts extrapolation to other healthcare settings with different infrastructural or educational contexts. Additionally, knowledge retention was only assessed at one post-intervention point, leaving long-term impacts unexamined. Observer and reporting biases may have influenced responses despite attempts to standardize data collection.

Future research should explore the longitudinal effects of educational interventions with follow-up assessments at multiple time points to assess knowledge retention and translation into clinical practice. Comparative studies involving different educational modalities—such as e-learning, simulations, and blended models—may help determine the most effective strategies for nephrology nursing education. Including a performance-based assessment or patient outcome metrics would further strengthen the evidence base linking knowledge gains to clinical effectiveness. Expanding this research to multi-center, diverse populations can also enhance its external validity and inform national training standards. This study reinforces the critical role of structured educational interventions in enhancing nurses' knowledge in hemodialysis management. While the findings affirm the program's immediate impact, they also reveal areas requiring intensified instructional focus. Future programs should integrate more interactive, scenario-based methods to better address complex domains and should aim for longitudinal reinforcement to ensure sustained clinical competence. The ultimate goal remains consistent: to empower nursing professionals with the knowledge and skills necessary to deliver safe, evidence-based care to patients undergoing hemodialysis.

CONCLUSION

This study demonstrated that a standardized educational intervention significantly improved nurses' knowledge and practices regarding the management of hemodialysis, with notable gains across critical domains such as fluid management, patient safety, and clinical procedures. The findings emphasize the importance of structured, evidence-based training programs in enhancing the competence of nursing personnel, thereby contributing to safer and more effective hemodialysis care. Clinically, these improvements are likely to reduce preventable complications and promote adherence to best practices in dialysis units. From a research perspective, the results support the continued development and evaluation of targeted educational models to strengthen nursing capacity in specialized care areas, with future studies encouraged to assess long-term retention, practical skill transfer, and patient-level outcomes.

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